

IoT based Product Recommendation System for Shopkeepers using Machine Learning

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Abstract - One of the biggest challenges faced by shopkeepers today is the need for more access to customer data and insights into their preferences and behavior. As a result, it can be difficult for shopkeepers to make informed decisions regarding restocking their inventory. In order to address this issue, a Product Recommendation System for supermarkets and shopkeepers has been developed that utilizes a smart trolley equipped with RFID (Radio Frequency Identification) technology based on the Internet of Things (IoT) to track items that customers place in their carts during shopping and process those items using a machine learning model to recommend products to the shopkeepers. This system not only automatically records the items purchased by the customers but also provides recommendations to shopkeepers based on data collected from customer shopping behaviours. By analyzing this data with machine learning algorithms, shopkeepers receive personalized restocking recommendations to optimize their stocks based on the most sold products and recommend such products to the shopkeepers so that their revenue increases.

Keywords - Recommendation System, RFID, IoT, Smart Trolley

1. Introduction

Currently, most supermarkets and department stores use a simple barcode system that requires store staff to scan the barcode with a laser scanner at specific locations within the store. This system is inefficient and time-consuming, as the barcode scanner requires the product to be in the line of sight and scanned one at a time, making it tedious for both staff and customers. Moreover, the COVID-19 outbreak has made it increasingly necessary to reduce crowds and speed up essential service processes, and the barcode system cannot provide adequate support during this crisis. The proposed solution is an IoT-based Smart cart system and Radio-frequency identification (RFID) that eliminates the need for long queues, reduces manpower, and makes the management system much more efficient for customers. The device will be installed on the shopping cart, allowing customers to scan their products themselves, generate a bill, make the required payment via a linked payment gateway, and provide recommendations to the supermarket owners and shopkeepers based on the number of units sold. The scanned product details will be updated on the retailer's database, which then will be processed using a machine learning model, enabling sales analytics to maximize their profit. RFID tags can be scanned at a long

range and integrated with security to provide an extra anti-theft measure. Incorporating all these components is necessary to provide a complete experience while still increasing the store's efficiency and security.

The proposed design is more functionally efficient than existing models in the industry. RFID readers are not widely used, and self-checkout services use barcodes as the ID instead. However, barcodes do not offer the same level of security as RFID and lack additional features such as real-time product tracking and inventory management. The RFID scanners used in shops are primarily handled by cashiers, and they are not designed for specialized product recommendations to shopkeepers so that they can stock their most sold products thereby they can increase their revenues. Artificial Intelligence Recommendation Systems for shopping that exist are not real-time and do not have a system in place to handle both shopping and recommendations for shopkeepers simultaneously. Therefore, while individual technologies exist in the domain, no product provides a comprehensive experience for both the shopkeeper and the user.

2. Literature Survey

With the increasing reliability and affordability of Internet of Things (IoT) connected smart devices in the shopping industry, it makes sense to utilize such technologies to alleviate the everyday stress of the average consumer. This research paper describes the implementation of a dependable, cost-effective, and intelligent Smart Shopping Cart, which is suitable for use in any physical retail store such as supermarkets. By automating the checkout process, this system can help reduce labor costs and improve the overall shopping experience for customers. Instead of having customers wait in long queues to check out their items, this system streamlines the payment process [3].

The adoption of RFID technology is rapidly increasing, and incorporating this technology into shopping carts is likely to enhance the customer experience while also simplifying the billing process. According to research, RFID and Zigbee can be used in conjunction with an application to create a centralized billing system for a shopping mall [2]. Customers can pay their bill using credit/debit cards, and their purchase history is stored in a local database for analysis. The system also interfaces with peripheral devices such as Zigbee, LCD, and a microcontroller, and allows users to add items to their cart and upload them to an online application that can be paid for using online wallets. Each user is provided with a membership card, which they swipe on the cart's sensor to upload items to their account. The shopping cart is equipped with an RFID scanner and a Zigbee module, through which user data is uploaded [2].

Typically, projects have utilized a Raspberry Pi module to enable users to upload data and host it on an online platform, allowing them to pay for their items through an online wallet and track the contents of their shopping cart. However, it is observed that all these existing systems lack user recommendations for similar products based on their shopping history, as well as an online database that records and stores logs of all user transactions. Furthermore, the products are not categorized to predict sales trends. When Zigbee and

microcontrollers are used, the data is not stored in the cloud but rather on a local device in the store, which prevents users from connecting their mobile devices to the system [9].

Recommendation systems are crucial in supermarkets. These intelligent engines, known as Recommender Systems, gather relevant information about a customer's previous purchases or product views to provide personalized suggestions on items they may find interesting [6]. By analyzing customer needs, these systems suggest the best possible shopping list. Customers generally appreciate these systems as they gain access to feedback given by other customers. Many applications utilize the products that a customer has purchased and rated to determine their interests. There are three popular algorithms used in recommendation systems: collaborative filtering, cluster models, and association rule mining. Collaborative filtering algorithms recommend products based on the opinions of other like-minded customers. Item-based and user-based collaborative filtering are the two types of collaborative filtering. In item-based collaborative filtering, similarities between items are calculated using cosine similarities, whereas user-based collaborative filtering uses historical information to identify the neighborhood for the active customer. Products are then recommended based on their similarity to this neighborhood. User-based recommender systems utilize customer profile data and can incorporate customer demographics along with purchase history data [6]. Recommendations for customers are determined by finding products that are similar to other products preferred by the customer. Cluster methods are used either in the case where a supermarket system recommends products to a new customer or in a new supermarket that lacks customer purchase history. This recommendation is based on textual clustering analysis provided in the product description.

3. Objective

The primary objective of the project is to provide shopkeepers with product recommendations based on the number of units sold and the item popularity. Initially RFID technology is integrated into shopping trolleys in order to achieve automated billing of items in the shopping trolley. The automation of billing eliminates the need for customers to wait in a queue in supermarkets. This will improve the customer experience. Every time the customer adds/removes a product into/from the shopping trolley, the RFID tag will be scanned and the user's cart that will be active in the server will be updated of the customer's actions. All the sales data will be stored in the database from where it will be fed as input to the recommendation system. The recommendation system is built to recommend the shopkeepers on a particular product and all of its related products based on the availability of the current stocks and arrival of new stocks. The machine learning model will analyze the popular products in the shop and recommend the shopkeepers with similar products for the shopkeepers to restock that ought to bring in more customers. This shall also enable the shopkeepers to manage the stocks better by collecting the necessary information such as the goods sold, available goods and to recommend the frequently sold products and their related products. This IoT based recommendation system allows for the shopkeepers to implement marketing strategies, to increase the sales of goods and services and make the business profitable.

4. Hardware and Technologies Used

4.1. RFID :

RFID stands for Radio Frequency Identification, which is a technology that uses radio waves to identify and track objects. RFID tags are small electronic devices that can be attached to or embedded in objects, and they contain a unique identifier that can be read by RFID readers using radio waves. RFID scanner can be used to scan the RFID tags embedded in the items in the shop. This technology is optimal for automation of billing.

4.1.1. Passive RFID :

Passive RFID tags are electronic tags that do not have a built-in power source, but instead rely on radio waves from an RFID reader to power them up and enable communication. Passive RFID tags are commonly used for applications such as inventory management, asset tracking, and supply chain management. In this project, the use of passive RFID tags is critical, as the scanner will have to read the tags when the item is put into the trolley.

4.2. ESP-32 :

ESP-32 is a modern technology that is low-cost, high-performance system-on-chip (SoC), low-power that is widely used for building Internet of Things (IoT) devices. It is based on the Xtensa LX6 CPU, which is a dual-core 32-bit processor. It is said to operate at up to 240 MHz. The ESP-32 SoC includes Wi-Fi and Bluetooth connectivity, as well as a wide range of peripheral interfaces, such as SPI, I2C, UART, and ADC. It also has built-in support for various protocols, including HTTP, MQTT, and CoAP, making it easy to connect to the Internet and communicate with other devices. The ESP-32 is popular for a wide range of IoT applications, including smart home devices, industrial automation, and wearables. ESP-32 plays a very important role in this project. This involves the updating of the bill hosted in the server.

4.3. Firebase :

Firebase is a cloud-based mobile and web application development platform. The real-time database is a NoSQL database that enables developers to store and sync data in real-time across multiple clients. Authentication allows developers to manage user authentication, while cloud storage enables them to store and share user-generated content, such as images and videos. Cloud messaging provides a reliable and scalable way to deliver messages to and from mobile and web applications, and hosting offers a simple and fast way to deploy web applications. Firebase also offers machine learning services, such as ML Kit, which is a mobile SDK that makes it easy to integrate machine learning features into mobile apps, without requiring any knowledge of machine learning. In this project, the data related to the shop's sales are to be stored in a realtime database. Hence Firebase is used to store and retrieve realtime data for feeding into the machine learning model.

4.4. Arduino Uno :

Arduino Uno is a microcontroller board. It is based on the ATmega328P. It is widely used in various electronic projects, including robotics, automation (especially home automation), and Internet of Things applications. There are 14 digital input/output pins in an Arduino Uno board. Out of 14 pins, 6 can be used as PWM outputs and 6 as analog inputs. A 16 MHz quartz crystal, a power jack, a USB connection, and an ICSP header are also parts of the Arduino Uno board. The board can be powered with an external power supply or via the USB connection.

4.5. Machine Learning :

Machine learning is a type of Artificial Intelligence that enables computers to learn and make predictions or decisions based on patterns in data, without being explicitly programmed to do so. In machine learning, algorithms use statistical techniques to learn from data and improve their performance over time. For this project the ideal type of machine learning algorithm is observed to be Collaborative Filtering.

4.6. Flask :

Flask is a web framework and it is widely used in building web applications using the Python. Flask is built on top of the WSGI toolkit and provides a simple and efficient way to handle HTTP requests and responses. It also provides many features, such as URL routing, template rendering, and form handling. Flask also has built-in support for secure cookies, sessions, and message flashing, making it easy to manage user authentication and data persistence. One of the key features of Flask is its modular design, which allows developers to add or remove components as needed, making it a highly customisable framework. Additionally, Flask integrates well with other Python libraries, such as SQLAlchemy for database access, Jinja2 for template rendering, and WTForms for form handling. Flask is used to display the output given by the machine learning model (i.e. Product Recommendation System) in a website that the shopkeeper can refer to.

4.7. Other minor components :

Other minor components used in the construction of the RFID Scanner for the shopping trolley are LCD Display, i2C Module, LED Indicators, Buttons and Buzzers.

5. Implementation

5.1. User Flow :

A shopping trolley is implemented in this section. This shopping trolley has been equipped with an RFID Scanner. This RFID Scanner is built with an RC522 RFID Reader, ESP-32 Chip, LED Indicator, LCD Display to display the required to the customer and a battery module that powers the whole system. The RFID Tags are attached to the items in the shop. Now when the customer decides to buy some item, they will take the item

and place it in their shopping trolley. This will trigger the RFID Reader to read the RFID tag attached to the item. The LCD display attached to the shopping trolley will display the updated number of items in the trolley. The item details and the price will be sent to the ESP-32 where the customer's bill shall be updated in the server. This is made possible because ESP-32 is equipped with a built-in Wi-Fi and dual mode bluetooth. The whole process is shown in Figure 1.

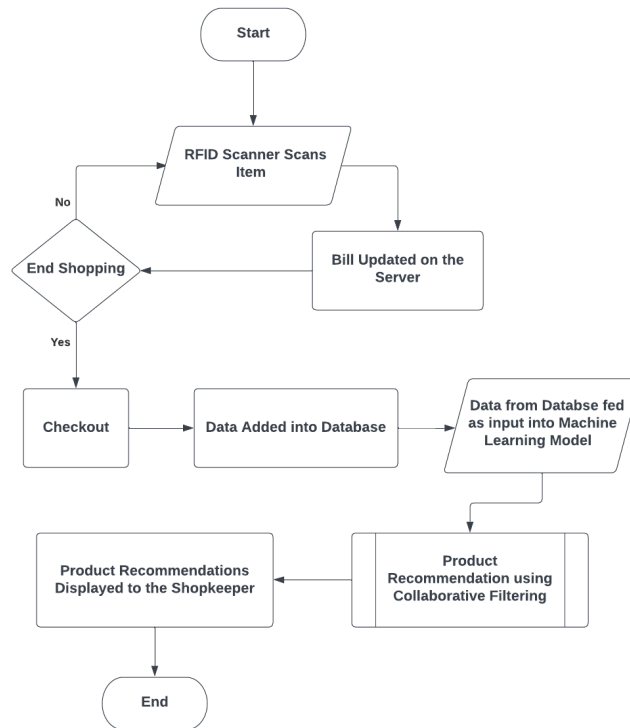


Fig. 1. Working of the System

After the customer is done with their shopping, their bill is immediately generated. The customer then just proceeds with the checkout, with no further hassle. This system later provides the shopkeepers with product recommendations. This recommendation works by the machine learning model receiving the sales and stocks data as input. Collaborative Filtering machine learning algorithm is used to build this product recommendation system. After the processing, the shopkeeper is presented with a list of products that are recommended for them to restock in their stock. (i.e. The shopkeeper has access to a list of items that are the most popular in their shop. Also they are shown a variety of similar products that the customers might be interested in.) This product recommendations will be displayed to the shopkeepers in a web-application dedicated to it.

5.2. Security :

RFID technology can help retailers prevent theft and loss of products. If an item with an RFID tag is removed from the store without being purchased, the system can automatically detect it and trigger an alarm.

Hence the use of RFID technology in security bars can help reduce losses due to shoplifting and improve security in the store.

5.3. Collaborative Filtering Recommendation System :

Collaborative filtering is used for building recommendation systems for e-commerce websites and other online marketplaces. In this context, collaborative filtering is used to make product recommendations to the shopkeepers based on the sales and item popularity.

To implement collaborative filtering for product recommendations, the first step is to gather data about user behaviour. This can include information about items that users have purchased, viewed, rated, or added to their shopping carts. Once this data has been collected, the next step is to identify patterns and similarities between users based on their behaviour.

To train the product recommendation system, the dataset consists of several items purchased by customers in a shop. The dataset used to train the machine learning model is from various supermarkets which consists of 18383 units sold. The raw dataset consists of the following parameters: Order ID, Product Name, Quantity Sold, Price of the item, Order Date and the Purchase Address. This dataset is then pre-processed, which now consists of the following parameters : Product Name, Quantity Sold and the Price of the item. Hence With this data the system will be able to identify the popular items in the shop, by comparing the sales of the items with the initial stock of the items. In this project, item-based approach of collaborative filtering is used, so that shopkeepers can be hit with several product recommendations. This approach will deal with the identification of items that are similar to the items that are identified to be popular in the particular shop. These identified items are then recommended to the shopkeepers. The similar products are identified with the use of K-Means Clustering. By using K-Means Clustering the system shall be able to figure out the correlation between two products. Also it will be able to detect communities of products that occur together. Considering two products A and B as example, suppose product A has seen a sales of 4000 units and product B has sold about 1400 units, then the popularity of those products can be combined with the help of the product recommendation system and can later be made to suggest some alternatives to the shopkeeper.

5.4. Prototype :

A prototype of the RFID Scanner system that shall be attached to the shopping trolley has been made using Tinkercad. This can be seen in Figure 2.

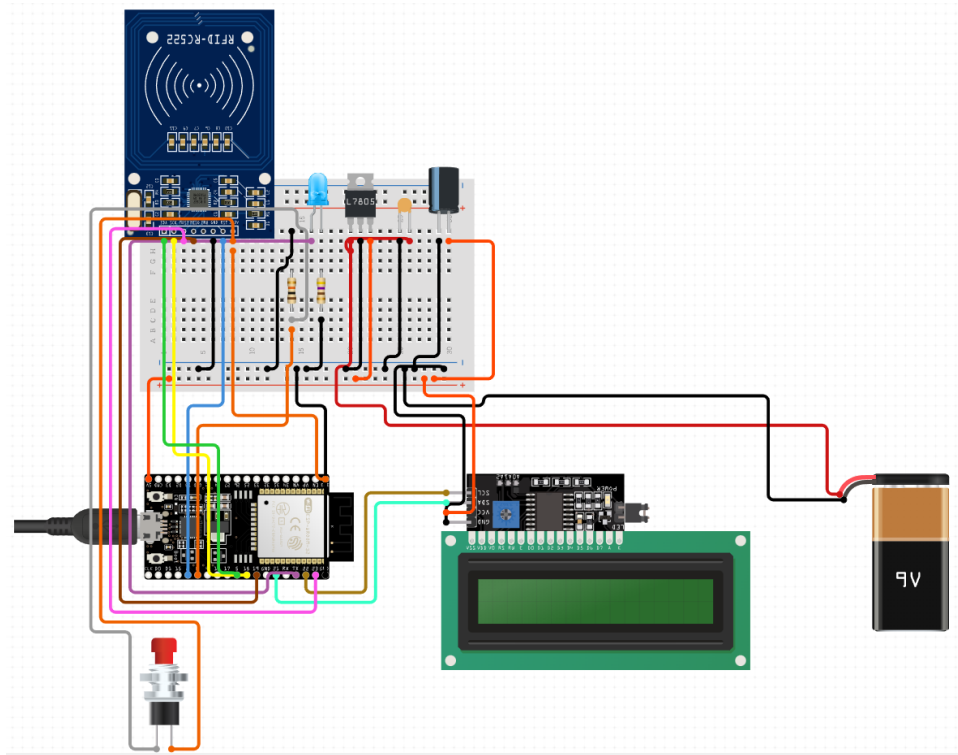


Fig. 2. Prototype of the RFID Scanner

The model consists of an ESP-32, EM-18 RFID Reader Module, a Battery Module, an LCD Display (16 x 2), LED indicator and a Button. The presence of ESP-32 eliminates the need for any other external components and extra connections thanks to its built-in internet module. The ESP-32 is powered by the battery module. The use of the LED indicator is it lights up indicating that a new item is added to the shopping trolley by the customer.

All these components are connected accordingly and attached to the shopping trolley. Thus, when a customer puts a new item into the shopping trolley the RFID tag of the item will be automatically read by the RFID scanner attached to the trolley. Also as a security measure, shops shall have RFID scanners in the security bars at the end of the shop in-order to prevent shoplifting. If the customer leaves the shop without proper removal of the RFID tag embedded in the item (RFID tags will not be removed for unpaid items), then the security bar shall raise an alert indicating the same.

5.5. Application Interface :

The shopping trolley that the customer will use to hold their items to be purchased will be fitted with a RFID scanner system that will scan the RFID tag of the item that the customer will put in the trolley. The ESP-32 will input the RFID unique code and sends it to the server where the customer's cart will be updated. The trolley will also be attached with a LCD display that will be connected to the scanning system. This LCD display will display the total number of items in the trolley and will be updated real-time. When the customer finishes their shopping the final bill will be generated after which the customer shall checkout. Firebase will then receive real-time updates on the items purchased by the customers. This will then be given as input to the machine learning model. The processing is done and the results (i.e. Product Recommendations for the shopkeeper) will be displayed in the web-application.

In the above process, it was mentioned that the ESP-32 will input the RFID unique code to the server. This unique RFIC code will be assigned to each and every item in the shop for unique identification. This will greatly help in the collaborative clustering product recommendation system generating a list of recommended items for the shopkeeper.

The key highlight of the application interface is the product recommendations that are listed in the web-application that is dedicated to that particular shopkeeper that enables them for a hassle free restocking. The Application Interface is as shown is Figure 3.

RECOMMENDED PRODUCTS				
Mobile Phones				
SNo	Name	Brand	Category	Ratings (out of 10)
1	iPhone 14 Pro	Apple	iPhone	9.5
2	S22	Samsung	Android Phone	6
3	Nord	OnePlus	Android Phone	8.5
4	iPhone SE	Apple	iPhone	7
Chocolates & Candies				
SNo	Name	Brand	Category	Ratings (out of 10)
1	Dairy Milk Silk	Cadbury	Milk Chocolate	6
2	Hersheys	Hersheys	Dark Chocolate	9
3	Sour Candy	Skittles	Candy	7.5
4	Tropical Candy	Skittles	Candy	7
Wrist Watch				
SNo	Name	Brand	Category	Ratings (out of 10)
1	Watch SE	Apple	Smartwatch	9
2	T-Touch Solar	Tissot	Premium Watch	7.5
3	G-Shock 3700	Casio	Sports Watch	9.5

Fig. 3. Application Interface

6. Results

The RFID scanning system makes checkout easier for customers by automating the billing process. At the same time, the Machine Learning Model enables the Product Recommendation System to recommend a list of products to the shopkeepers based on item popularity and the customer purchase.

The accuracy of this product is validated based on the sales. Figure 4 shows the purchase and sales data of the following months: December 2022, January and February 2023. It is clearly observable that the purchase and the sales of February 2023 is the lowest among the three months. Without the product recommendation engine, the shopkeeper has failed to restock items that were popular in their store. This crisis can be eliminated, if the shopkeeper makes use of the product recommendation engine and restocks the items that are recommended by the recommendation system. This clearly shows the critical need for the RFID-enabled product recommendation engine in offline stores in-order to increase their sales and also provide ease of purchase for the customers.

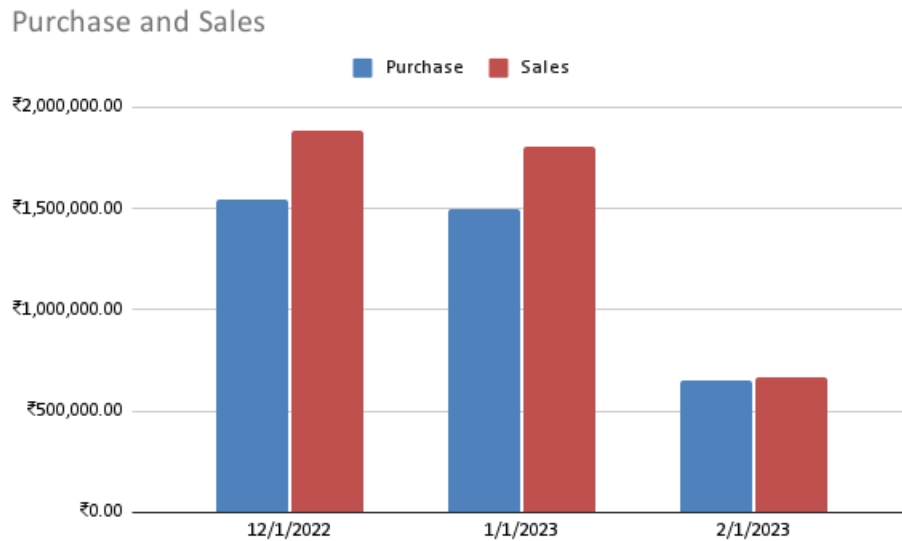


Fig. 4. Comparative Analysis of Purchase and Sales

7. Conclusion and Future Scope

This project has made use of a newer technology, a RFID scanner embedded in shopping trolleys for providing the customers with a hassle-free, shopping experience. This greatly reduces the need for hands-on service in offline stores in terms of billing and security as RFID security bars detect unpaid items. At the same time the shopkeepers are also benefitted with products recommendations for their shop. The shopkeepers can restock heavily on the items recommended by the product recommendation system. This is because of the collaborative clustering converging successfully and providing satisfactory results.

This proposed system when implemented in a full fledged way in offline stores, then it will eliminate the need for a person at the billing section. Also it will speed up the process of checkout for the customers, resulting in improvement of the customer experience.

The proposed Product Recommendation System for Shopkeepers when implemented, will increase the shop's sales as it tends to recommend products based on the previous sales and item popularity. But before this recommendation system is implemented into the real world, the machine learning model shall be made more adaptive so that the accuracy and the effectiveness of the model can be highly improved.

In today's world, barcodes are the typical means of billing. But with RFID tags getting cheaper, this might see a significant change in the future. Considering the fact, that RFID scanning and billing also proves to be much secure, it may be the future of standard billing in offline stores.

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